THE GENERAL MOVEMENT OF TYPHOID FEVER AND TUBERCULOSIS IN THE LAST THIRTY YEARS.

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Professor Finkelnburg, of Bonn, estimates that the average length of human life in the sixteenth century was only between eighteen and twenty years, and at the close of the eighteenth century it was a little over thirty years, while today it varies in different countries from less than twenty-five to more than fifty years. The span of life since 1880 has been lengthened in civilized countries about six years. No two factors have contributed so much to the general results as the improvements of the air we breath and the water we drink. Indeed, we have ample evidence that with the introduction of public water supplies and sewers the general mortality in numerous cities during the past fifty years has been reduced fully one-half, the good effects being especially shown by a marked decrease in the number of deaths from typhoid fever, diarrhœal diseases, and consumption. The vital statistics of Great Britain furnish the proof,[1] and our experience with American cities confirms this conclusion.

The death rate in the city of Berlin has been reduced from 32.9 in 1875 to 16.4 in 1904; in Munich, from 41.6 in 1871 to 18 in 1906; and in Washington, from 28.08 in 1875 to 19.25 in 1907. The death rate in the city of New York in 1804 was 28 per 1000; from 1850 to 1854 it was 38 per 1000; while in 1906, in spite of the density of

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[1] The following table shows the death rate from certain diseases per 10,000 of population in the English cities before and after the introduction of sanitary works (see Cameron, A Manual of Hygiene, 1874, p. 129):

	Typhoid fever	Diarrhœa.	Consumption.
Bristol, before sanitary works	10.0	10.5	31.0
Bristol, after sanitary works	6.5	8.1	25.5
Leicester, before sanitary works	14.7	16.0	43.3
Leicester, after sanitary works	7.7	19.3	29.3
Cardiff, before sanitary works	17.5	17.2	34.7
Cardiff, after sanitary works	10.5	4.5	28.6
Macclesfield, before sanitary works	14.2	11.0	51.5
Macclesfield, after sanitary works	8.5	9.0	35.3
Warwick, before sanitary works	19.0	5.7	40.0
Warwick, after sanitary works	9.0	8.0	32.3
Stratford, before sanitary works	12.5	11.2	26.6
Stratford, after sanitary works	4.0	5.7	26.5
Ashby, before sanitary works	13.3	4.0	25.5
Ashby, after sanitary works	5.7	8.3	31.3
Dover, before sanitary works	14.0	9.5	26.5
Dover, after sanitary works	9.0	7.0	21.2
Croydon, before sanitary works	15.0	10.0	...
Croydon, after sanitary works	5.5	7.0	..

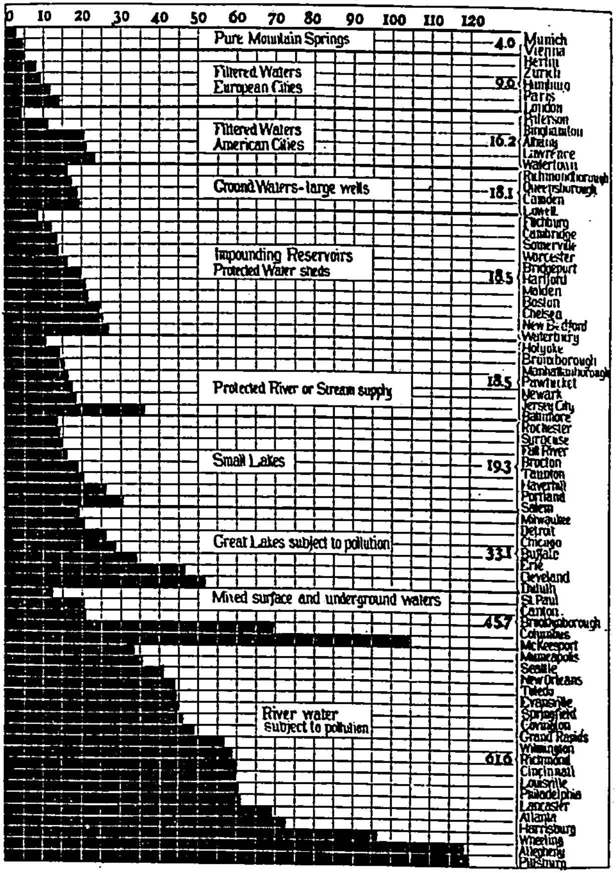
the population, it was 18.9 per 1000, practically a reduction of 50 per cent., which, according to Walter F. Wilcox,[2] of Cornell University, means a saving of something like 46,000 lives each year in that city alone.

The mortality in the registration area in the United States has been reduced since 1890 from 19.6 to 16.2 per 1000 in 1905. Taking the census figures of a population of 33,757,811 in the registration area as a basis, the number of deaths in 1905 was 544,533; whereas at a rate prevalent in 1890, they would have been 662,654, a reduction of 17.8 per cent. and a saving in one year of 118,121 lives. If the same rate is applied to the entire estimated population in the United States of 82,574,195, the saving of human lives during 1905 alone would be over 290,000.

It has long since been known that rivers are always purer near their source; the amount of impurities increases as we descend the stream, since the water courses are the natural drainage channels of the country and the wastes of human life and occupations find their way into the streams. It is also well known that our large American rivers are the sewers and at the same time the source of water supply for nearly all the cities located on their banks. These cities show, moreover, a marked prevalence of typhoid fever, thus confirming what has been observed over and over again, that this disease, as also cholera, dysentery, and diarrhœal diseases can be carried from one town or city to another by means of inland waterways. Indeed, the question is one of extreme interest even to the residents along the Great Lakes; we know that large cities like Buffalo, Erie, Cleveland, Detroit, and Milwaukee discharge their sewage into the lakes, and we also know how Chicago and Cleveland suffered from typhoid fever visitations by contaminating their own water supplies. It is also a well-known fact that many of the river cities were obliged to resort to purification of their water supplies in order to arrest the ever-increasing typhoid fever wave.

INFLUENCE OF WATER SUPPLIES UPON TYPHOID FEVER DEATH RATES. For the purpose of determining the influence of public water supplies on the typhoid fever death rates in general, Mr. M. O. Leighton, Chief of the Water Resources Branch of the U. S. Geological Survey, very courteously complied with my request for a list of the principle American cities with a population of over 30,000 classified according to their water supply. Dr. Cressy L. Wilbur, Chief Statistician of Vital Statistics, Bureau of the Census, with equal promptness and accuracy, has computed the mean rate (not the average annual rate, which, however, differs only slightly for the five years 1902 to 1906), and has arranged them in a diagram (Chart I). The statistics, in spite of the many factors concerned in the dissemination of typhoid fever, conclusively show that the water

[2] Monthly Bulletin, New York State Dept. of Health, March, 1908.



MEAN DEATH RATES FROM TYPHOID FEVER, 1902 TO 1906, IN 66 AMERICAN CITIES AND 7 FOREIGN CITIES. GROUPED, AFTER FUERTES, ACCORDING TO THE QUALITY OF THEIR DRINKING WATER. THE RATES FOR FOREIGN CITIES ARE TAKEN FROM JAMES H. FUERTES.

CHART I.

supply plays the most important role in the spread of the disease. A summary of the typhoid fever death rates is here given:

	Mean typhoid fever death rate from 1902 to 1906 per 100,000 of population.
4 cities using ground water from large wells	18.5
18 cities using impounded and conserved rivers or streams	18.5
8 cities using water from small lakes	19.3
7 cities using water from the Great Lakes	32.8
5 cities using both surface and underground water	45.7
19 cities using poluted river water	61.1

The rates for cities using unpurified river water fluctuate from 33.1 at Minneapolis to 122.1 at Allegheny, and even 133.1 at Pittsburg.

GENERAL MOVEMENT OF TYPHOID FEVER. Chart II illustrates the general movement of typhoid fever in different countries and cities, showing the percentage of decrease from the first to the last period shown. The period covered by Dr. Wilbur is (nearly) the last quarter of a century, and the rates are usually given for the successive five-year periods, beginning with 1881. The table shows that during the last twenty-five years the death rate from typhoid fever has fallen in these fourteen countries and cities from an average of 42.3 to 18.1 per 100,000, a reduction of 54.3 per cent. A more striking reduction could have been made if statistics going back as far as 1870 had been included. The typhoid rate in Berlin in 1872, at a time when that city was riddled with cesspools and supplied with polluted water, was as high as 142 per 100,000. On account of the incomplete mortality returns everywhere prior to 1881, we have deemed it best to exclude all older foreign statistics, and for similar reasons Dr. Wilbur begins his statistics for the United States with 1890.[3] We have likewise excluded Mr. Whipple's statistics, which tend to show that the death rate from typhoid fever in twelve States, including all of the New England States, New York, New Jersey, Maryland, California, Minnesota, and Michigan, has fallen from 55 in 1880 to 21 per 100,000 in 1905.

THE HYGIENIC VALUE OF PURE WATER: ANNUAL COST OF TYPHOID FEVER IN THE UNITED STATES. According to the Census of 1900, there were 35,379 deaths from typhoid fever during the

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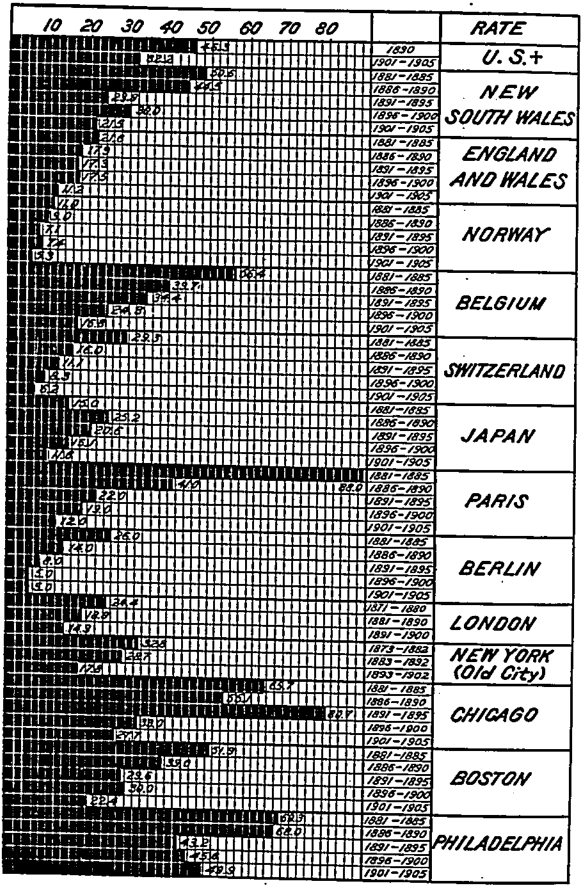
[3] Dr. Wilbur obtained the foreign statistics from data compiled from the international figures given in the last report of the Registrar General of England and Wales, from which report the rates for London are also taken. The rates for the cities of Paris and Berlin are given in the Annuaire Statistique of the City of Paris for the year 1904, and the rate of Berlin for the period 1901 to 1905 was supplied by Dr. Wilbur from data in his office. Dr. Wilbur laments the fact that "it is even now difficult to obtain a satisfactory statement of the number of deaths from such an important disease as typhoid fever in certain foreign countries, and the difficulty of securing comparative data increases as we go back. The disease was first accurately compiled by the Registrar of England in 1869."

TYPHOID FEVER

DEATH RATE PER 100,000 OF POPULATION



+Registration area

CHART II.

census year throughout the United States; and based on an estimated mortality of 10 per cent., it is within reason to assume a yearly prevalence of 353,790 cases of this disease. If we calculate the average cost for care, treatment, and loss of work to be $300, and the average value of a human life at $5,000, we have a total loss in the United States of $283,032,000 from one of the so-called preventable diseases. Mr. George C. Whipple[4] presents some striking evidence to indicate that a loss of $10,000 for every death from typhoid fever is a conservative estimate, in which case the decrease in the "vital assets" during the census year of 1900 would amount to $353,790,000. Reduce the prevalence of the disease one-half (which has been accomplished in Europe and our own country), and the question of the hygienic value of pure water will be answered from an economic point of view.

THE EFFECT OF IMPROVED WATER SUPPLY ON TYPHOID FEVER DEATH RATES. Chart III shows clearly the effect of change in water supply on typhoid fever death rates in seven American cities. Dr. Wilbur, of the Bureau of the Census, has given the death rate for a considerable time before and after the date of change, and also the average annual death rate before and after purification, and the percentage of reduction. From this table we learn that the combined average annual death rate from typhoid fever in cities with a contaminated supply was 69.4, and after the substitution of a pure supply it fell to 19.8 per 100,000, a reduction of 70.5 per cent.

The *Bulletin* for the month of April, 1908, of the New York State Department of Health contains an interesting article showing that the death rate from typhoid fever in ten cities of that State has been reduced 53.4 per cent. by improved water supplies.

It may be urged that improved methods of medical treatment are responsible for a considerable reduction in the death rates from typhoid fever, but when we see such a striking change immediately after the installation of filtration plants as in the case of the American cities shown in Chart III, and also more recently in Cincinnati and Philadelphia, we are forced to the conclusion that water purification plays the most important role by diminishing primarily the number of cases. It should be stated, however, that the effects are still more marked when combined with a good system of sewerage. The history of every sewered town shows a lessening of the typhoid death rate, and that the typhoid rate is always higher in sections of the same city supplied with makeshifts. In 1895 I pointed out that typhoid fever prevailed in Washington in 1 of 81 houses supplied with privies, and in only 1 in 149 of those connected with sewers, and offered as the only reasonable explanation that the sewers carry away the filth and germs that otherwise would contaminate the soil and ground water; but even if there were no wells,

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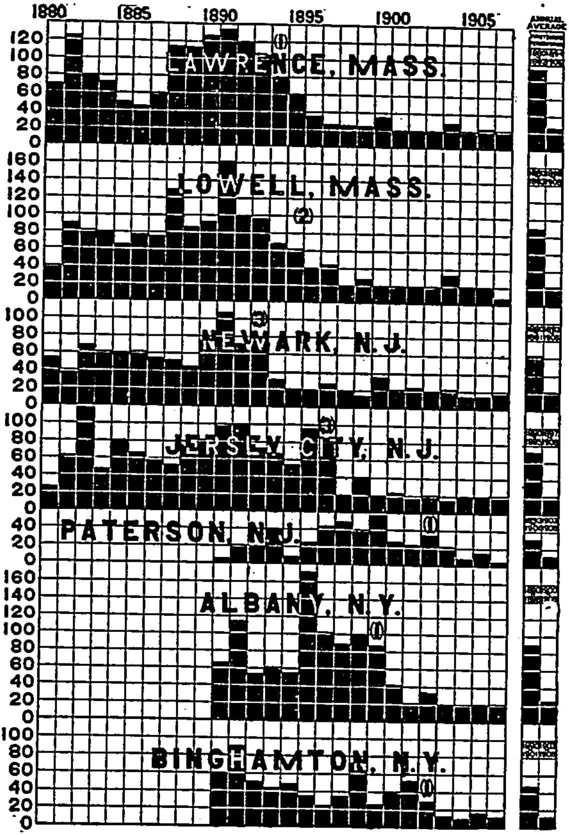
[4] The Value of Pure Water, New York, 1905, p. 5.

TYPHOID FEVER

DEATH RATES PER 100,000 OF POPULATION



CHANGE IN WATER SUPPLY

(1) From unfiltered river supply to filtered river supply
(2) From unfiltered river supply to wells
(3) From polluted river supply to conserved river supply

CHART III.

these makeshifts are still a source of danger in so far as they favor the transmission of the infection by means of flies; nor can the possibility be ignored that the germs in leaky or overflowing boxes may reach the upper layer of soil and with pulverized dust gain access to the system.

I believe that about 80 per cent. of the cases of typhoid fever are water- and milk-borne, and about 20 per cent. may be spread through the agency of flies, personal contact, the consumption of raw oysters and shell fish raised in sewage polluted waters, or the eating of strawberries, radishes, celery, lettuce, and other vegetables and fruits which have been contaminated with infected night soil.

OTHER WATER-BORNE DISEASES. What has been said of typhoid fever is equally true of other water-borne diseases, like cholera, dysentery, cholera morbus, diarrhœal diseases, and the transmission of intestinal parasites, because the germs or ova of these diseases are present in the intestinal tracts and presumably also in sewage contaminated water. Mr. Allen Hazen,[5] one of the most distinguished experts on water purification in America, has conclusively shown that as the result of filtration plants in five cities supplied previously with an impure water, there was not only a reduction of 81 per cent. in the deaths from typhoid fever, but also a marked reduction in the general death rate. His computations clearly indicate that where one death from typhoid fever has been avoided by the use of a better water, a certain number of deaths, probably two or three, from other causes have been avoided. The truth of Hazen's theorem has recently been confirmed by Professor Sedgwick. It is a difficult matter to explain how water is connected with the deaths other than those from water-borne diseases, yet when we consider that water enters into the composition of the human body to the extent of 60 per cent., we are in a position to appreciate the sanitary acumen of Aristotle when he wrote in his *Politica:* "The greatest influence on health is exerted by those things which we most freely and frequently require for our existence, and this is especially true of water and air."

The general importance of the subject is now fully appreciated, and the North American Conservation Conference, on February 23,

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[5] See a paper read at the International Engineers' Congress at St. Louis in 1904. Mr. Hazen found in five cities where the water supply had been radically improved:

	Per 100,000
A reduction in total death rate with the introduction of a pure water supply	440
Normal reduction due to a general improved sanitary condition, computed from average of cities similarly situated, but with no radical change in water supply	137
Difference being decrease in death rate attributable to change in water supply	303
Of this, the reduction in deaths from typhoid fever was	71
Leaving deaths from other causes attributable to change in water supply	232

1909, in the declaration of principles adopted the following in reference to Public Health:

"Believing that the conservation movement tends strongly to develop national efficiency in the highest possible degree in our respective countries, we recognize that to accomplish such an object with success the maintenance and improvement of public health is a first essential.

"In all steps for the utilization of natural resources consideration of public health should always be kept in view.

"Facts which cannot be questioned demonstrate that immediate action is necessary to prevent further pollution, mainly by sewage, of the lakes, rivers, and streams throughout North America. Such pollution, aside from the enormous loss in fertilizing elements entailed thereby, is an immediate and continuous danger to public health, to the health of animals, and, when caused by certain chemical agents, to agriculture. Therefore, we recommend that preventive legislation be enacted."

Having studied the effects of pure water supplies upon mortality rates, let us next consider the influence of pure air, removal of dampness, and general sanitation upon the movement of tuberculosis.

THE INFLUENCE OF SEWERS IN THE PREVALENCE OF TUBERCULOSIS. The records of the Health Office of the City of Washington show that during the last thirty years 14.5 per cent. of all the deaths occuring in the District of Columbia have been caused by pulmonary tuberculosis. The death rate, however, has gradually and constantly fallen from 446 per 100,000 in 1880 to 280 in 1907. The death rate from this disease in New York City has fallen in like manner from 433 to 271; in the United States at large, from 326 in 1880 to 183 in 1907 (Chart IV). These reductions began long before the combat of the disease was a subject for popular education. The question naturally arises, if these reductions have resulted independently of any attempt to control the source of infection, what are the chief factors concerned in bringing about this gratifying result? I know of no sanitary reforms which could have exerted a greater influence upon our general well-being than the introduction of sewers, improved water supplies, and the erection of sanitary homes. The marked reduction in the prevalence of consumption after the introduction of sewers observed in England over forty years ago, and also in the cities of Washington and New York and the country at large, may fairly be attributed to the prevention of air pollution and dampness. It is noteworthy that while the reduction in Washington, coincident with the introduction of sewers, amounts to 37.3, the reduction in Baltimore, an unsewered city, is only 24.7 per cent. It has been estimated by Erismann that a cesspool with 18 cm. contents is capable of polluting the atmosphere in the course of twenty-four hours with 18.79 cm. of impure gases, composed of carbonic acid, ammonia, sulphuretted and carburetted hydrogen, and volatile fatty acids. In view of this fact, it requires no great stretch of the imagination to calculate the amount of air pollution which resulted from the 30,000 cesspools and other makeshifts prior to the introduction of the sewerage system in the city of Washington. The influence of impure air upon our physical well-being and the powers of resistance cannot be over-rated. As a matter of fact, individuals who contract tuberculosis in cities often arrest the disease by removal to the country, showing that an abundance of pure air is a very important factor in the treatment of the disease, simply because it promotes oxygenation of the blood, stimulates the appetite and nutrition, and thereby increases the general resisting power of the system. There can be no doubt as to the curative virtues of pure air, and hence we ought not to under-rate its preventive properties.

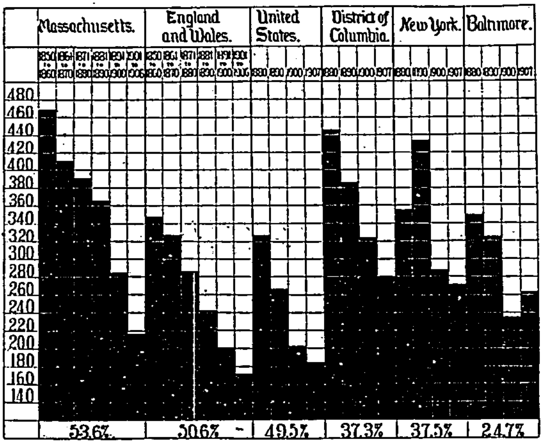

CHART IV.—General movement of tuberculosis. Death rates per 100,000 of population and percentage of reduction.

The observations of Dr. Bowditch, of Boston, as early as 1862, clearly indicate that there is a relation between dampness of soil and pulmonary consumption, and Dr. George Buchanan, the Medical Officer of the Privy Council of Great Britain, in 1867, supplied ample statistical proof that consumption became less frequent in certain towns after they had been sewered and the soil consequently drained. In towns like Worthing, Rugby, and Salisbury the deaths from consumption were reduced by 36 to 49 per cent. It is true that such a marked reduction did not always follow, but in these instances it may be fairly assumed that the soil was previously quite dry and could not be materially affected by increased drainage.

The importance of a dry, healthful building site was appreciated by Hippocrates, since he, as well as Vitruvius, the father of architecture, referred in their writings to elevation as a desirable factor. One of the most striking illustrations of damp habitations as a predisposing cause to consumption has been recorded by Nowak, in the case of a prison in the vicinity of Vienna, containing on an average 200 inmates. Every convict is examined before his transport, and if found affected with incipient tuberculosis he is sent elsewhere. In spite of this precaution, the deaths number about fifty per annum, and the majority die from consumption. The prisoners are better fed in this institution than elsewhere, but the building rests on a wet soil, the walls are reeking with moisture, and the rooms smell musty.

The relation of dampness to consumption may be explained as follows: Dampness of soil, unless special precautions have been taken, extends by capillary attraction to the walls and renders the entire house damp. Damp air abstracts an undue amount of animal heat, lowers the power of resistance of the inmates, and predisposes to catarrhal affections, and these in turn render the mucous membrane, more vulnerable to the invasion of the tubercle bacilli. There is also reason for believing that the tubercle bacilli retain their vitality for a greater length of time in such an atmosphere on account of its humidity and excess of organic matter.

At all events, it has long been known that tuberculosis is far more prevalent in damp, dark, and insanitary houses. The children are anemic and as puny as plants raised without the stimulating effects of sunlight. The death rate is often double and treble that of other localities. While there are doubtless other factors which determine the frightful mortality, none are more potent than dampness, and deficient sunlight and ventilation. The tubercle bacillus clinging to floors and walls in carelessly expectorated sputum or droplets would be destroyed by a few hours' exposure to sunlight, but it finds in damp and dark basements, back-to-back houses, and yard and alley tenements suitable environments for its vitality and growth, and the other insanitary factors alluded to, together with the more intimate contact, materially increase the chance of infection.

If it should appear from the foregoing that I believe in the ubiquity of the tubercle bacillus, and that the question of environment should receive first and foremost consideration, I desire it to be understood that I am convinced, from the splendid labors of Professor Carl Fluegge, that the tubercle bacillus is not ubiquitous, and hence the task of stamping out the primary sources of infection is by no means hopeless. I believe, however, that until this is accomplished, in this disease as in other infectious diseases, due attention should be given to all the causes likely to influence their spread, so that in our efforts to combat tuberculosis they may receive proper consideration.

I can scarcely do better than to conclude with the following quotation from the Report of the Conservation Commission:

"Since the greatest of our national assets is the health and vigor of the American people, our efficiency must depend on national vitality even more than the resources of the minerals, lands, forests, and waters. The average length of human life in different countries varies from less than twenty-five to more than fifty years. This span of life is increasing wherever sanitary science and preventive medicine are applied. It may be greatly extended. Our annual mortality from tuberculosis is about 150,000. Stopping three-fourths of the loss of life from this cause and from typhoid and other prevalent diseases would increase our average length of life fifteen years. There are constantly about 3,000,000 persons seriously ill in the United States, of whom 500,000 are consumptives. More than half this illness is preventable. If we count the value of each life lost at only $1700, and reckon the average earnings lost by illness at $700 a year for grown men, we find that the economic gain from mitigation of preventable disease in the United States would exceed $1,500,000,000 a year. This gain, or the lengthening and strengthening of life which it measures, can be had through medical investigation and practice, school and factory hygiene, restriction of labor by women and children, the education of the people in both public and private hygiene, and through improving the efficiency of our health service, municipal, State, and national."

EXPERIMENTS RELATING TO THE BACTERIAL CONTENT OF THE FECES, WITH SOME RESEARCHES ON THE VALUE OF CERTAIN INTESTINAL ANTISEPTICS.

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The great number of bacteria present in the intestinal tract has for many years been a source of great interest to the physicians, and many investigations have been undertaken to determine the number and nature of these organisms. It has been demonstrated that the great proportion of the organisms consists largely of but